The Relation (Ratio) Between the Average and Maximum Velocities During Turbulent Motion in Pipes

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[Note: the following report appeared in the regular Hydromechanics section of the thrice-monthly journal Doklady Akademii Nauk SSSR, Volume 79, No. 3 (21 July 1951), pages 405-6. It had been submitted by academician A. I. Nekrasov, 31 May 1951.]

Up until now there has been no theoretically based formula for determining the dependence of the field coefficient (ratio of average flow velocity to the maximum), during turbulent motion in smooth pipes, upon Reynolds' number. Now this formula is obtained in a perfectly elementary manner from Prandtl's equation (1):

$$(U_{max} - V)/U_* = D \qquad (1)$$

(U_{max}, U_*, V are respectively the maximum, dynamical, and average velocity, and D is Prandtl's constant), and from the formula for the coefficient of friction (2):

$$1/\sqrt{\lambda} = 1.8 \lg (Re/7) \qquad (2)$$

in the following way:

Utilizing the familar relation $U_* = V\sqrt{\lambda}/\sqrt{8}$ in place of (1), we have $U_{max}/V = 1 + D\sqrt{\lambda}/\sqrt{8}$. (3)

Substituting (2) into (3), after transformations we obtain $V/U_{max} = (5.08 \lg Re - 4.30)/(5.08 \lg Re - 4.30 + D)$. (4)

Assuming D = 4.30 (according to experiments of Nikuradze, the quantity D fluctuates from 3.8 to 4.6), we have:

$$f_v = \frac{V}{U_{max}} = 1 - 0.845/\lg Re \qquad (5)$$

The agreement of experience and theory in the entire range, encompassed by measurements, of Reynolds' number is

completely satisfactory as is evident from figure where the experimental data of Nikuradze (3) is plotted in dots.

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Cited Literature

(1) I.I. Agroskin, F. I. Pikalov, and G. T. Dmitriyev. Hydraulics [Gidravlika], 1950.

(2) A. D. Al'tshul'. Doklady Akademii Nauk SSSR, Volume 76, No. 6 (1951).

(3) Problems of Turbule [illegible], Symposium under the Editorship of M. A. Velikanov [[illegible]y turbulentnosti, sbornik pod redakt. M. A. Velikanova]. Moscow: 1936.

[figure 1 follows]

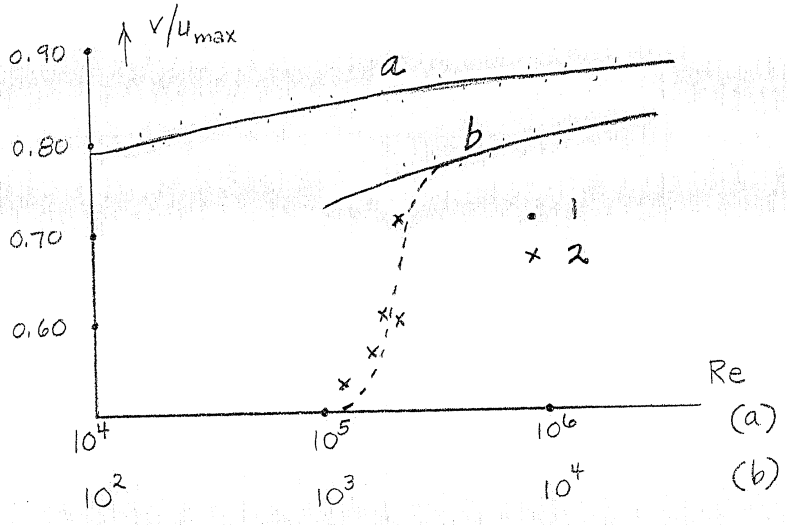

Figure 1. Dependence of the ratio of average velocity to maximum velocity upon Re (theory and experience).

$V/U_{max} = 1 - 0.845/\lg Re$.

1 - Nikuradze

2 - Stenton.

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